LED 101:

# Specifying LEDs for Electronic Assemblies

EBW Electronics

## LEDs are strongly associated with energy efficiency, that is only one of many benefits offered by the technology.

In many applications, such as those found in the automotive and electronic industries, the reduced form factor of LED circuit boards reduces material and space requirements while offering greater flexibility for design and manufacturing. To complement this, LEDs offer a long service life and have minimal maintenance requirements.

The use of LED circuit boards and LED lighting is projected to grow as more opportunities for improvement in manufacturing are exploited. The US Department of Energy forecasts that 48% of lighting shipments by 2020 will be LED-based. The report further projects that, by 2030, LED lighting will account for over 80% of all lighting shipments.[1]

When specifying LEDs in electronic assemblies, designers must balance the qualities of LEDs to achieve the optimal solution.

## FACTORS TO CONSIDER INCLUDE:

**1. Color and Color Rendering Index**
**2. Brightness**
**3. Direction**
**4. Efficiency**
**5. Life Expectancy**
**6. Thermal management**
**7. Performance**

# 1 COLOR

The color of white LED is defined by its *color temperature*, or **CCT**. Color temperature defines the warmth or coolness of a light, as LED lights are measured on a scale ranging from the warmest (more red) to coolest (more blue) color.

*Color rendering*, or **CRI**, of a light source measures how saturated colors will be when illuminated by that source. A lamp with a CRI of 1 will render colors perfectly, while colors illuminated by a low CRI source will illuminated some or all colors poorly. Typical white LEDs have a CRI ranging from 0.7 to 0.8, and the best ones have CRI values over 0.9.

Monochromatic LEDs are available in any of the primary colors, and monochromatic LEDs can be mixed to produce nearly any color in the visible spectrum. By modulating the light produced by multiple monochromatic LEDs, a product can be built with color adjustment and dimming capabilities.

- LEDs can be configured to produce color-coded alarms and notifications. An example of this are the indicator lights used in smartphones, which produce a different color for each type of notification. This color flexibility is also very useful in industrial settings, where a single control panel may be used to monitor multiple processes, each with its own set of customized alarms and signals.

- Decorative purposes: Color-adjustable LEDs can be used in car interiors and electronic gadgets to offer a high degree of customization for the end user. If wireless communication features are added, LEDs can be controlled remotely through a smartphone application.

  LED components with adjustable color output normally use one of the following configurations:

- **RGB** – Red, green and blue monochromatic LED chips.

- **RGBW** – Red, green, blue and white LED chips.

- **Tunable White** – White LEDs of different color temperatures can be used to "tune" the color temperature.

## RGB AND RGBW LED

When these configurations are used, the output of each LED chip is modulated so that the combined output yields the desired color. With the combination of red, green and blue wavelengths, it is possible to generate almost any color in the visible spectrum.

Although both configurations can produce a broad range of color outputs, the RGBW configuration offers the following advantages:

- When white light is required, the white LED chip can produce a higher quality output (CRI) than the combination of red, green and blue.
- The extra chip adds variety to the range of color outputs that can be achieved.

## TUNABLE WHITE LED

The same principle used in RGBW LED chips can be applied here to produce tunable white light. LED chips tuned for different color temperatures can be mounted on the same component and dimmed independently. Their combined output can produce warm white of any color temperature, typically ranging from warm white (2700K) to cool white (6500K).

# BRIGHTNESS

LED brightness is measured in *lumens*. **Lumens** are a measure of the total amount of light produced. It is a fundamental measurement in the sense that other units of light measurement often refer to lumens. The fundamental output of a lamp is usually specified in lumens, often referred to as “total luminous flux”, which means “lumens.” **Lux** is a measure of how much light is incident per unit area (lumens per square meter), and so is a measure of how brightly an area is illuminated. For example, the surface of your desk might be illuminated at 10 lux.

The **Candela** is a measure of how focused a light source is (lumens per steradian). So, for example, a 100-lumen spotlight will have a much higher candela than a 100-lumen floodlight. The **Nit** is the unofficial name of luminance, the measure of light emitted from a surface in a particular direction. The output of a video screen or indicator lamp is measured in Nits. LED output is always specified either in Lumens or in Candela.

# DIRECTION

An LED may or may not have a lens, and so may be available with different directivity.  Since LEDs are small light sources, it is fairly easy to use secondary optics (reflectors, lenses) to focus light the way it is desired. Each individual chip concentrates lighting in a narrow beam directly above it, which means an LED array can be designed to produce a very precise lighting distribution, something that is not possible with incandescent and HID bulbs. This provides significant advantages when designing and manufacturing car headlights, for example:

- LED headlights can be designed so that no light is projected towards the eyes of drivers coming in the opposite direction, eliminating glare issues and contributing to road safety during nighttime.
- At the same time, the optical design of LED headlights can be optimized so that a powerful beam of light is projected towards the road and its sides, enhancing visibility.

Due to their size, halogen and HID bulbs allow less control over the direction which light is emitted, making it more difficult to control glare. These light sources also emit a high amount of concentrated heat when mounted in compact arrays, which limits configuration options; on the other hand, LED chips allow components of any shape and lighting distribution to be manufactured.

# 4 EFFICIENCY

Thanks to their superior efficacy, LEDs need less current than older lamp types to produce a given luminous output. They are more efficient as compared to compact fluorescent lamps, halogen lamps, linear fluorescent luminaires, and incandescent lamps.

The best white LEDs provide about 150Lm/W, which is around 20% efficient. 80% of the energy delivered to an LED is lost as heat. The best fluorescent lamps produce about 100Lm/W, and so LEDs can outperform them. The best incandescent lamps produce about 15Lm/W, which is about 2% efficiency.

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The size of circuit components is determined in great part by the current they carry, so reducing total power drawn translates into more compact circuit boards. This provides a series of efficiencies throughout the manufacturing process:

- Less materials are required to manufacture the circuit boards.
- Transportation costs are decreased due to the weight reduction.
- When power comes from a battery, which is common in small-scale applications, the low energy consumption of LED components helps increase the duration of each charge.

# 5 HEAT

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Thermal management in LED lamps is critical because the additional heat is a problem. In an incandescent lamp, for example, all the waste heat is radiated as infrared radiation, but in an LED, the light fixture must dissipate it. LED fixtures require heat sinks. An LED headlight, though efficient, may have a heat sink the size of a shoe box to dissipate the waste heat.

Heat sinks are designed to direct the heat from the LED source to an outside medium, where it can be safely and efficiently dissipated. Heat sinks can dissipate power in three ways: conduction (heat transfer from one solid to another), convection (heat transfer from a solid to a moving fluid, for most LED applications the fluid will be air), or radiation (heat transfer from two bodies of different surface temperatures through thermal radiation).

As it relates to PCBs, thermal management includes separating the LED drive circuitry from the LED board to prevent the heat from raising the LED junction temperature. Boards with metal cores, typically consisting of aluminum alloy, may leverage a dielectric polymer layer with high thermal conductivity for lower thermal resistance.

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# SERVICE LIFE

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LED components are low-maintenance and have a long service life, due to the fact they are solid-state devices, free from electrodes and filaments. For example, it is possible to swap a 1000-hour halogen headlight or a 2000-hour xenon headlight for an equivalent LED product offering a service life of over 20,000 hours. This prevents plenty of lamp replacements while contributing to fuel economy in the long run. It is important to select a qualified manufacturer, however, since there are many low-quality custom LED products in the market, which are likely to fail prematurely.

LED life expectancy, however, is system parameter not an LED parameter all by itself. LED specifications allows LED manufacturers to extrapolate a 6000-hour test to a 35,000-hour lifetime performance. Meeting that life requires properly designing the lamp to drive the LEDs in their safe operating area, and doing proper thermal management to keep them from getting too hot.

That said, a well-designed LED lighting product is estimated to last for up to 100, 000 hours. Longer lifespans can be achieved by integrating suitable smart controls such as occupancy sensors.[2] As compared to incandescent lamps, LEDs can work longer by up to 50 times.

# RESTRIKE

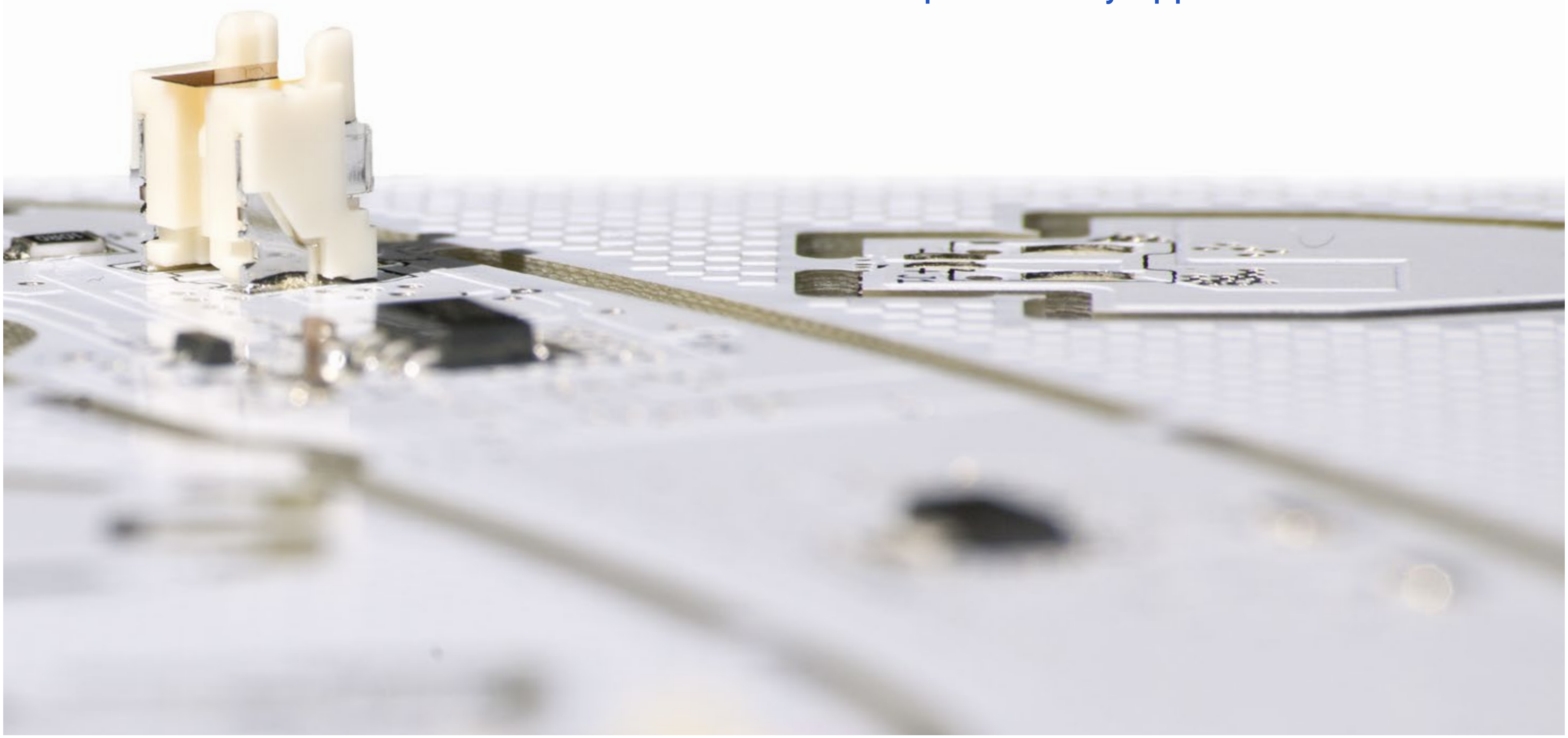
*LEDs attain full brightness output almost instantly.*

LEDs attain full brightness output almost instantly. They do not require warm up time or restrike time delay. In comparison, traditional lighting technologies need a warm up time to produce full brightness. For instance, most compact fluorescent lamps take at least 3 minutes to provide full light output.

As compared to CFLs, HID lamps require longer warm up times of up to 10 minutes or more. For example, high-pressure sodium lamps require warm up times of over 10 minutes to provide full brightness. In addition, high-intensity discharge lamps require restrike time delays of up to 20 minutes after a turn off.[3]

Smart controls such as day light sensors and occupancy sensors depend on on-off operations. Such operations have no negative effects on the lifespan of LEDs. In comparison, rapid on-off cycles have deleterious effects on most traditional lighting technologies such as compact fluorescent lights and halogen lamps. An increase in the number of on-off cycles causes the electrodes to erode thereby decreasing the lifespan of the lamp. In the case of HID lamps, their long restrike and warm up times do not allow rapid on-off cycling. The high tolerance of LEDs to frequent switching is significant in electronic devices, control panels and automotive applications, where indicator lights are switched frequently, perhaps hundreds of times per day in some applications.

With their compact size, long service life, manufacturing flexibility, color adjustment capabilities and compatibility, easier controllability, and instant full brightness output, LED circuit boards can be adapted for any application.



# WHERE GREAT PEOPLE MAKE GREAT PRODUCTS

EBWE is a world leader in LED circuit boards and LED applications, specializing in design and electronic manufacturing of printed circuit board assemblies. Originally a part of a larger company and now a widely respected expert in electronics design and manufacturing, EBW Electronics continues to evolve with the times while staying true to its family atmosphere.

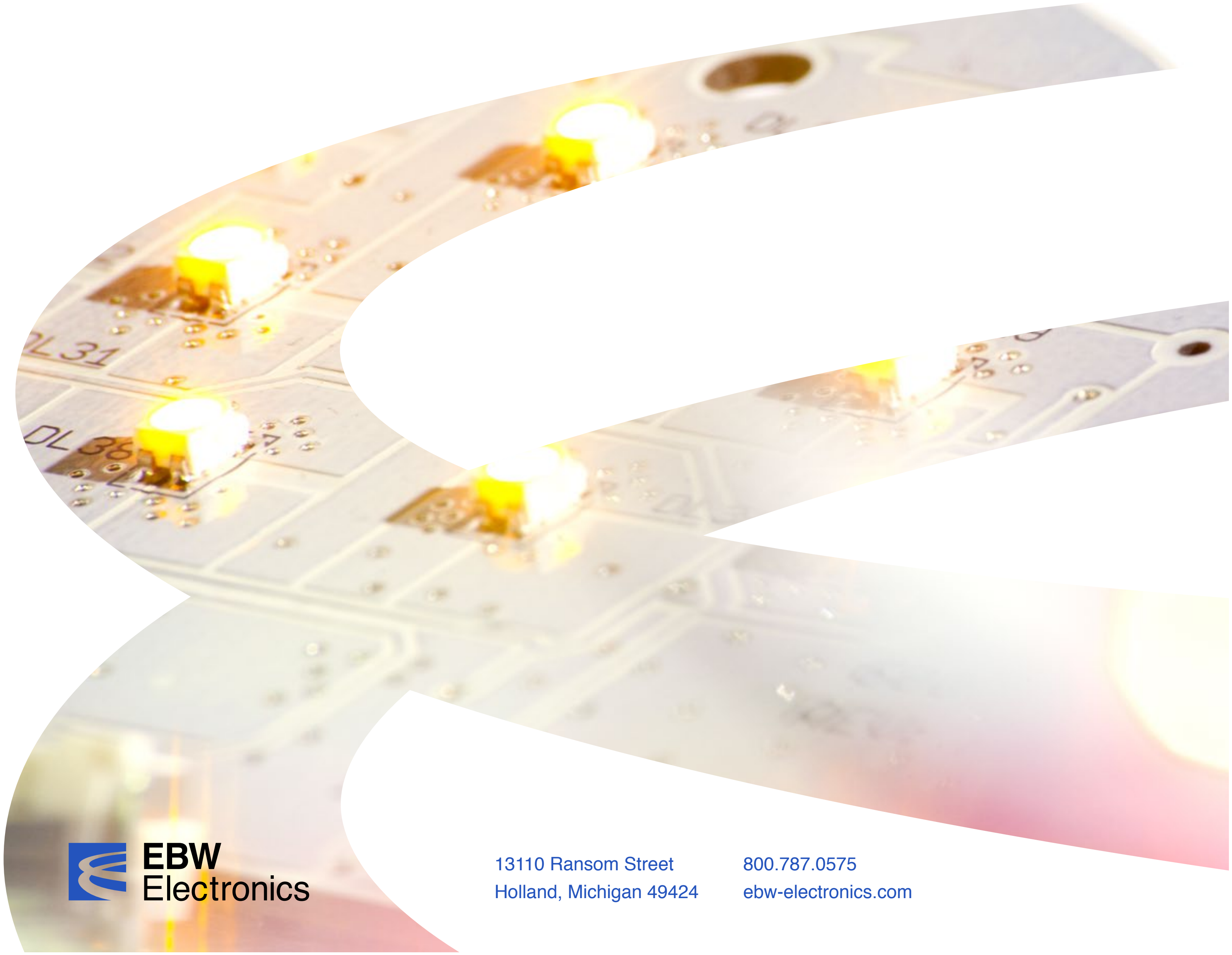
Our team-oriented approach and desire for quality keep everyone working toward the same goal: making a quality product efficiently.


REFERENCES

**[1]** DOE SSL Program, "Solid-State Lighting R&D Plan," May 2015. [Online]. [Accessed Jan 2017].

**[2]** The Climate Group, "Lighting The Clean Revolution: The Rise of LEDs and what it means for cities," June 2012. [Online]. [Accessed Jan 2017].

**[3]** DOE Building Technologies Program, "Solid-State Lighting Technology Fact Sheet," January 2012. [Online]. [Accessed Jan 2017].




**EBW Electronics**

13110 Ransom Street
Holland, Michigan 49424

800.787.0575
ebw-electronics.com